Quantum Mechanics & Special Relativity Review

1. **Special Relativity**
   1st Postulate: The laws of physics are the same in all reference frames
   2nd Postulate: Nothing can travel faster than 'c'

2. **Time Dilation & Length Contraction**
   Time Dilation: time slows as objects approach the speed of light

   $$t = \frac{t_o}{\sqrt{1-\frac{v^2}{c^2}}}$$

   Length Contraction: objects moving at high speeds appear shorter

   $$L = L_o\sqrt{1-\frac{v^2}{c^2}}$$

3. **Mass Dilation**
   Objects moving at speeds approaching the speed of light gain mass

   $$m = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$$

4. **Mass-Energy Equivalence**
   The momentum and energy of an object are affected by the speed of the object. Objects travelling at speeds approaching the speed of light, experience mass dilation which in turn affects the momentum and energy of the object.

   $$p = \frac{m_o v}{\sqrt{1-\frac{v^2}{c^2}}}; \quad E = m_o c^2 + E_k$$

5. **Elementary Particles**
   Leptons: have no internal structure
   Quarks: smallest unit of matter
   Hadrons: made up of quarks
      Mesons: consist of a quark and antiquark
      Baryons: consist of three quarks
   Bosons: force carrying particles

6. **Quantum Theory**

Fundamental problems with wave theory:

- The energy of a system is finite
- Light exhibits the property of momentum
- Particles exhibit the property of diffraction

Light travels is packets of energy called quanta

- $E_\gamma = hf$; $E_\gamma = \frac{hc}{\lambda}$

7. **The Photoelectric Effect**

Energy is transferred from incident photons to the electrons in a metal

$E_k = E_\gamma - W_0$ where $E_k = eV_0$

If $E_\gamma < W_o$ no photoelectrons appear

If $E_\gamma = W_o$ the photoelectrons are stopped at the metal surface

If $E_\gamma > W_o$ the photoelectrons are ejected

The cut-off potential is the minimum potential required to prevent electrons from being ejected from the metal surface.

8. **de Broglie & Matter Waves**

Light behaves as both a wave and a particle

$\lambda = \frac{h}{p}$ or $\lambda = \frac{h}{mv}$

9. **Probability Waves**

Each particle is represented by a wave function, Ψ (position, time), which represents the probability of finding the particle at that position at that particular instant in time.

10. **Heisenberg's Uncertainty Principle**

If we know the position of a particle, we cannot know its momentum and vice versa.

$\Delta p_y \Delta y \geq \hbar$

If we know the energy of the particle, we cannot know the length of time it has that energy and vice versa.

$\Delta E \Delta t \geq \hbar$

11. **Questions**

- Page 661 #1, 4, 5, 6, 7, 9
- Page 735 #10, 11
- Page 742 #2, 3, 4, 5, 12, 13, 14, 23, 24, 28, 30